

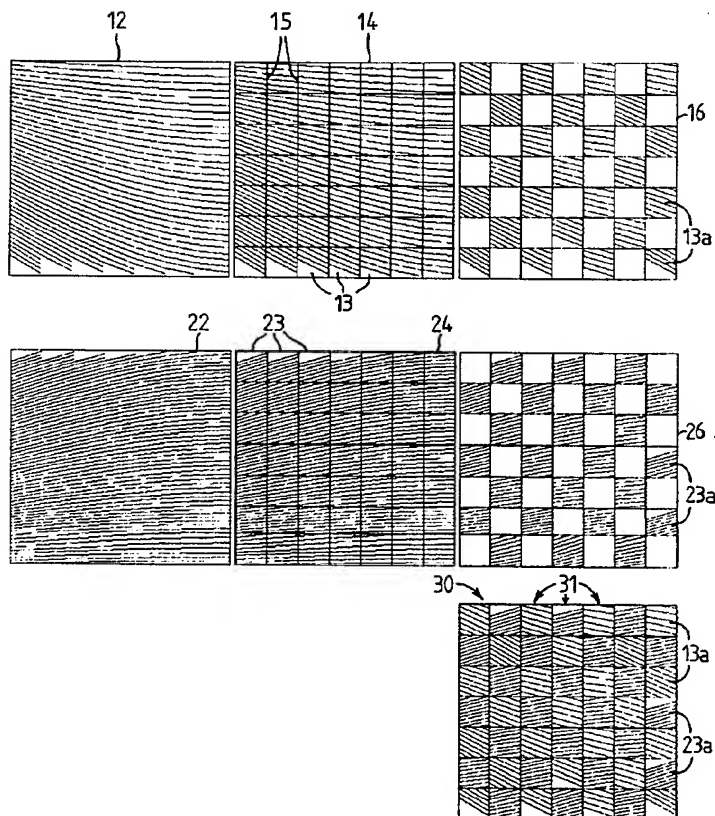


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : G02B 5/18, 27/44, B44F 1/12, B42D 15/10, 209/00	A1	(11) International Publication Number: WO 94/28444 (43) International Publication Date: 8 December 1994 (08.12.94)
(21) International Application Number: PCT/AU94/00279 (22) International Filing Date: 25 May 1994 (25.05.94) (30) Priority Data: PL 9000 25 May 1993 (25.05.93) AU (71) Applicant (for all designated States except US): COMMON-WEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION [AU/AU]; Limestone Avenue, Campbell, ACT 2601 (AU). (72) Inventor; and (75) Inventor/Applicant (for US only): LEE, Robert, Arthur [AU/AU]; 13 Wilkins Street, East Burwood, VIC 3125 (AU). (74) Agents: NOONAN, Gregory, J. et al.; Davies Collison Cave, 1 Little Collins Street, Melbourne, VIC 3000 (AU).		(81) Designated States: AU, CA, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: MULTIPLE IMAGE DIFFRACTIVE DEVICE**(57) Abstract**

A pixellated diffractive device includes a multiplicity of pixels (12, 22) in turn divided into multiple sub-pixels (13, 23). The device is related to one or more pixellated diffraction surface structures which when illuminated generate respective corresponding optically variable images. The sub-pixels (13, 23) of each pixel of the diffractive device include diffractive elements (13a, 23a) arranged in one or more groups, the diffractive elements of each group matching diffractive elements of a corresponding single pixel of the respective pixellated diffraction surface structures. In each pixel of the device the diffractive elements (13a, 23a) of the or each said group are intermixed with other sub-pixels and cooperatively contribute a single element of the corresponding optically variable image which is generated on illumination of the diffractive.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

MULTIPLE IMAGE DIFFRACTIVE DEVICE

Field of the Invention

5 This invention relate to diffractive devices and to their manufacture and has particular though not exclusive application to the provision of optically variable security diffractive devices which may be adapted for affixment to or incorporation in, for example, currency notes, credit cards, charge cards, share certificates and the like.

10 Background Art

The present applicant's international patent publication WO91/03747 (application PCT/AU90/00395) proposes a diffraction grating structure comprised of a multiplicity of pixels which are individual optical diffraction gratings so that the
15 pixellated diffraction grating when illuminated generates an optically variable image. The applicant's pixellated diffraction gratings utilising curved line grating pixels have become known by the trademark Pixelgram (trade mark). According to preferred aspects of the arrangement disclosed in the international application, the respective diffraction grating of each grating pixel comprises a plurality of reflective or
20 transmissive grooves or lines which are usually curved across a pixel. Groove or line curvature determines both local image intensity, e.g. shading, and local optical structural stability. Groove or line spacing in each pixel determines local colour properties, with non-primary colours generated by a pixel mixing. Average groove or line orientation determines movement or colour effects, and the number of
25 distinct values of average curvature and average spacing may be viewed as defining the Pixelgram palette, by analogy with the language of computer graphics. A further disclosure of a security diffraction grating structure is to be found in international patent publication WO90/07133 (PCT/AU89/00542).

The present applicant's international patent publication WO93/18419 (PCT/AU93/00102) discloses how selected visually observable effects in the optically variable image may be generated by arraying the pixels in groups within which the pixels are arranged according to a predetermined rule for the pixellated diffraction

grating. Thus, for example, multiple sets of different images, or of the same image but different shading or colour, may be produced at different viewing angles.

The concept of providing multiple optically variable images at different viewing angles, using a pixellated diffractive device in which each pixel contains a sub-pixel corresponding to each image, is also disclosed in US patent 5,032,003. In that case, each diffractive sub-pixel is a straight line grating. This is an example of a more general class of pixellated diffractive structures utilising straight line grating pixels and known by the trademark Kinegram.

Australian patent application 10499/92 proposes a pixellated diffraction grating structure with three channels which constitute views from different angles of the same image, in order to obtain a stereoscopic image. The gratings may be curved line gratings. A predecessor of this reference is Japanese patent (Kokai) publication 2-72320.

European patent publication 467601 is concerned with holographic diffraction grating patterns which may include curved line gratings. Overlaid or alternate channels are proposed for providing different images at different angles. The different images may include numerical information and logos.

Summary of the Invention

20

The present inventor has now appreciated that the concepts of the aforementioned applications can be further extended to provide diffractive devices which give one or more optically variable images, by fracturing the pixels of each image into sub-pixels and then rearranging and interlacing the sub-pixels so that the sub-pixels cooperatively provide elements of the respective images. In proposing this further development, the inventor has appreciated that he can take advantage of the mathematical theorem in Fourier analysis that the Fourier transform of any diffractive function is translationally invariant.

The invention accordingly provides, in one aspect, a pixellated diffractive device comprising a multiplicity of pixels in turn divided into multiple sub-pixels, which device is related to one or more pixellated diffraction surface structures which when illuminated generate respective corresponding optically variable images. Sub-

pixels of each pixel of the diffractive device include or consist of diffractive elements arranged in one or more groups. The diffractive elements of each group match diffractive elements of a corresponding single pixel of the respective pixellated diffraction surface structures. In each pixel of the device the diffractive elements of
5 the or each said group are intermixed with other sub-pixels and cooperatively contribute a single element of the corresponding optically variable image which is generated on illumination of the diffractive device.

The invention also provides, in another aspect, a method of deriving at least a representation of a pixellated diffractive device, comprising a multiplicity of pixels
10 in turn divided into multiple sub-pixels, which method comprises deriving at least a primary representation of each of one or more pixellated diffraction surface structures which when illuminated generate respective corresponding optically variable images, fracturing each pixel of the or each said primary representation into multiple diffractive elements, and deriving at least a secondary representation of said
15 pixellated diffractive device by forming each pixel thereof so that sub-pixels thereof include or consist of diffractive elements arranged in one or more groups, the diffractive elements of each group matching diffractive elements of a corresponding single pixel of the respective said pixellated diffraction surface structure, wherein in each pixel of the device, the diffractive elements of the or each said group are
20 intermixed with other sub-pixels and cooperatively contribute a single element of the said corresponding optically variable image.

In some prior references, the term "relief structure" is utilised interchangeably with or instead of "diffraction grating" or "diffraction surface structure". The term "diffraction surface structure" is employed herein to indicate a structure which is
25 either reflective or transmissive. Without in any way limiting the scope of "diffraction surface structures", it is noted that such structures may include, for example, line or groove diffraction gratings, small squares, rectangles or polygons.

By "at least a representation" is meant that the respective integer may be actually formed, or, if not, at least a representation is formed. The representation
30 may be a set of code or data defining the respective integer, e.g. in a computer memory means. The aforesaid deriving steps are preferably carried out in suitably programmed computer operations. The method may advantageously include the step

of utilising the derived representation to drive a suitable machine, e.g. an electron beam lithography machine, to form the actual diffractive device.

Preferably, there are at least two optically variable images, each associated with a respective group of diffractive elements. The images may be the same or
5 similar scenes but differently oriented or of different shading or colour. One or more further groups of sub-pixels of the device may collectively generate an optically invariable image.

There are preferably at least four sub-pixels per pixel, but more preferably at least 16 in a 4 x 4 square array of square sub-pixels. The pixels are preferably
10 sufficiently small to be below the resolution limit of a healthy human eye, for example, less than 125 micron on edge and more preferably about 30 to 80, e.g. around 60 micron.

The diffractive sub-elements are preferably dispersed within each pixel so as to produce a predetermined discernible effect in the corresponding optically variable
15 image. The dispersal of the diffractive elements may be chosen from a predetermined set of selections which therefore defines a mapping palette for the diffractive element array, again by analogy with the language of computer graphics. In a case where, in accordance with international patent publication WO91/03747, the respective diffraction surface structures forming the pixels of the pixellated
20 diffraction surface structure have been formed, e.g. in relation to predetermined variables such as groove or line curvature, groove or line spacing and average groove or line orientation, from a primary palette, the aforementioned mapping palette forms a secondary palette and the diffractive device entails successive selections from both the primary and secondary palettes.

25 The diffractive elements within the pixels may involve classes of miniature diffraction gratings of curved and variably spaced grooves, or alternatively elementary arrays of polygon shaped relief structures (pixels within pixels or SQUOTS) of dimensions of the order of fractions of a micron. In general the transformed representations of the input images may involve classes of groups of diffractive
30 elements. A class of different groups of diffractive elements is defined as a component palette of component pixel types. Since each element of a component palette is itself a group of diffractive elements, each diffractive element can be

regarded as a member of a sub palette and hence each component palette is, in this embodiment, a palette of sub palettes (palettes within palettes).

The invention therefore also provides, in a further aspect, a method of forming a pixellated diffractive device in terms of a multiplicity of diffraction grating
5 palettes wherein each palette contains miniature diffraction grating groups and each group M is in itself a sub-pixel palette of N sub-pixel diffractive elements comprising defining the device by repeating each group M at predetermined locations within a large array of repeat group locations, the map of repeat group locations for each group M being determined by a set of complex mapping relations between the large
10 array and a set of invariable image component maps which act co-operatively under the control of the mapping relations to define the diffractive properties of the diffractive device thereby formed on said large array.

As already indicated, the images generated by the diffractive device may be either optically invariable or optically variable. An image is described herein as
15 "optically variable" where it varies according to the position of observation and "optically invariable" where it remains substantially the same regardless of the position of observation. By "image" in the context of this specification is meant the optical image observed by the naked eye focussed on the diffractive device when it is illuminated by an arbitrarily extended diffuse source of finite width such as a
20 fluorescent tube. The term "image" is used herein in its broadest sense, not being limited to pictorial or diagrammatic images but extending, e.g. to figures, numbers, data and codes.

It is an advantage of the present invention that the diffractive device may produce not only a mix of optically variable and optically invariable images but may
25 also produce two or more different kinds of optically variable images. For example, the optical variable images may be of a Pixelgram type (i.e. each pixel is a curved line diffraction grating), a Kinegram type (i.e. each pixel is a straight line diffraction grating), or a mathematical hologram. For each case, the structure of the component mapping palettes is determined by the optical properties of the input images and the
30 required optical properties of the component viewable images generated by the diffractive device.

The diffraction device may be provided on a suitable substrate, eg a metal

foil, and/or may be affixed or formed in a carrier eg a currency note, credit card, bank account or ATM card, debit card, security card, charge card or prepaid card.

Brief Description of the Drawings

5

The invention will now be further described, by way of example only, with reference to the accompanying diagrams, in which:

Figure 1 is a diagrammatic representation of the formation of an embodiment of diffractive device in accordance with the invention, the diffractive device
10 generating two different optically variable images and utilising Pixelgram-type curved line diffraction gratings; and

Figure 2 is a diagrammatic representation of a further embodiment of the invention; and

In Figures 1 and 2, the optical effect arising from slight discontinuities or
15 steps in the grating lines is a printer artefact.

Description of Preferred Embodiments

Figure 1 depicts one pixel 12,22, for each of two pixellated diffraction gratings
20 designed in accordance with the principles set out in international patent publication WO91/03747 and intended to produce respective different optically variable images when illuminated. The two pixels are preferably at corresponding coordinate positions in the respective gratings. It will be understood that each of the diffraction gratings does not necessarily physically exist at this stage and that each of the two
25 illustrated pixels may merely have been designed in a computer system and this design set down as a representation in the form of a set of stored data, or more preferably as a code for a selection from a Pixelgram palette, as further discussed hereinafter.

As explained in international patent publication WO91/03747, the contents
30 of which are incorporated herein by reference, the respective pixellated diffraction gratings are produced from an optically invariable image by first dividing up the image into square pixels (in this case 62.5 micron squares) and assessing the greyness

factor, chroma or colour value, or more specifically the greyness factor, chroma or colour value of each pixel in turn. This process is typically carried out by exposing an image to a video camera coupled to a suitable computer system, the greyness factor for each pixel being stored in the computer memory. Groove or line curvature
5 across a pixel determines both local image intensity, e.g. shading and local optical structural stability. Groove or line spacing in each pixel determines local colour properties, with non-primary colours generated by a pixel mixing. Average groove or line orientation determines movement and colour effects, and the number of distinct values of average curvature and average spacing may be viewed as defining
10 the pixelgram palette by analogy with the language of computer graphics. The lines are derived from a function $S_{ij}(x,y)$ as more fully explained in international patent publication WO91/03747.

It is emphasised that the diffraction grating pixels 12,22 may be pixels of other forms of pixellated diffraction surface structure, e.g. Kinegram-type structures or
15 holograms.

The next step is to fracture or divide the respective pixels 12,22 into multiple diffractive elements 13,23. A preferred fracturing is a simple $n \times n$ square array, depicted in Figure 1 as a grid overlay 15. In this example, it is a 7×7 array 14,24
20 of square diffractive elements 13,23 of almost 9 micron sides, a total of 49 diffractive elements.

The set of diffractive elements is then sampled and displaced or rearranged so that approximately half of the diffractive elements of each set are rearranged in an even, spaced out array 16,26. It will be seen that the two arrays 16,26 are preselected so that, in each array, the retained diffractive elements 13a,23a occupy
25 mutually exclusive positions. The two arrays can then be merged or interlaced to produce the combined pixel 30 in which the diffractive elements 13a,23a define a complete set of sub-pixels 31. In this simple case, sub-pixels 31 consist of diffractive elements 13a,23a.

This process may then be repeated for all the corresponding pixels of the two
30 designed Pixelgram-type gratings. The resultant set of pixel representations, in the form of suitable data or code, is applied to an electron beam (or "E-beam") lithography system to produce the real grating. E-beam machines are particularly

suitable for etching out a diffraction grating microgroove pattern in a substrate in accordance with the supplied data or codes. This aspect of the process is already known and is described, e.g., in International patent publication WO91/03747. In a practical application, a master diffractive device designed to generate characteristic
5 images is made by the above method, and this master is subsequently utilised to produce authorised copies. The grating may be typically written as an array of square cut reflective grooves in a metallised surface, for example PMMA electron resist spin coated onto a chrome coated glass substrate. This substrate may then be processed to produce a gold coated nickel master. For example, a durable metal
10 master of the optimised grating may be obtained by vacuum coating the photo-resist master with 2000 angstrom 99.99% gold and electro-depositing a thick layer of nickel to act as a support. After separating from the glass master, this gold coated nickel master may be bonded to a brass block and used as a dye for hot pressing of authorised plastic film/foil replica gratings.

15 It will be seen from Figure 1 that the design of the arrays 16,26 involves in some instances a substantial rearrangement of the relative positions of the diffractive elements within the pixel. Thus, their relative spatial arrangement is substantially different from their arrangement within original pixels 12,22, in which the diffractive elements co-operate as a contiguous surface structure. For example, the diffractive
20 elements are not merely spread out but occupy different co-ordinate positions in the array. On the one hand, because of the aforementioned theorem of Fourier analysis, this does not effect the integrity of the combined contribution of the diffractive elements or sub-pixels to the corresponding single element or pixel of the viewed optically variable image. On the other hand, observable effects can be produced in
25 the viewed image by particular relative rearrangements of the diffractive elements within a pixel. It is also necessary to take account of the loss of half of the diffractive elements. Thus, for example, it has been realised that in a diffraction grating pixel such as 12, the closest spaced lines towards the left and towards the bottom control the positive order components of the image generated when the
30 grating is illuminated, and the greater spaced region towards the right and top more controls the negative order components. Thus, if the diffractive elements 13a retained in the array 16 are chosen more from the region towards the bottom left

corner of pixel 12, there will be a strong positive bias in the contribution to the pixel of the image. A set of selections of different rules for sampling and displacing the diffractive elements 13,23 of the fractured array 14,24 can be predetermined as a secondary palette for the system.

5 Some examples of other effects able to be produced by respective selections from the secondary palette include:

- (i) An "RGB" palette consisting of red, green and blue sub-palettes which together act cooperatively to produce a true colour image of the subject at one angle of view. The red, green and blue sub-palettes have carrier frequencies which
10 differ slightly from each other, but the same range of greyness factors;
- (ii) Transparency effects produced by an optically variable Pixelgram-type image in one component with a generalised grating as the second component;
- (iii) An optically invariable image in one component and an optically
15 variable image as the second component. The optically invariable image sub-palette consists of a palette of diffusely diffracting pixels of different levels of greyness which produce a static image in zero-order.

It will now be understood that the general case combining the primary and secondary palettes can be viewed as a set of N component palettes with M1 elements
20 in the first component palette, M2 elements in the second palette ... and MN elements in the Nth component palette.

It will be appreciated that the fracturing, sampling/displacement and recombination steps in accordance with the preferred practice of the invention allow the production of complex multi-component diffractive devices for which the images
25 have a much smoother appearance, since the effective image resolution can be increased due to the grid size being reduced to the size of a 5 to 15 micron diffractive element or sub-pixel rather than a full, e.g. 60 or so micron, pixel. The effective palette size has also been increased by the fracturing and sampling technique since it allows for the mixing in of additional specialised sub-pixels.
30 Finally, fracturing, sampling and recombination allows for much more flexibility in assigning image element characteristics to the mathematical properties of the sub-pixels.

A number of further embodiments are possible within the general concept of the invention. For example, the sampling process involved in deriving the array 16,26 from the fractured pixel 14,24 may involve choosing only $(n \times n/2)M$ diffraction elements from each pixel and then interlacing $2M$ sub-pixels not chosen from the
5 main fractured pixels, with specialised optical properties, to fill the remaining areas of the eventual array. These additional sub-pixels may be designed to contribute special diffuse light effects, zero order diffraction effects or applications-specific colour switch effects to the final image.

In another alternative embodiment (Figure 2), also indicated as secondary
10 palette (ii) above, a Pixelgram-type pixellated diffraction grating 40, shown here as generating an optically variable image recognisable as Albert Einstein, may be combined with a non-pixellated generalised diffraction grating 42 consisting of a curved groove pattern with variable spacings between the grooves. The result is a diffractive device 45 which under illumination produces one or more optically
15 variable semi-transparent images embedded in a background diffractive field. Because the background generalised grating is relatively slowly varying when compared to the very small scale pixellated grating pattern, the background grating pattern will produce relatively large scale zero-order Talbot or Moire fringe patterns when the diffractive device is copied using holographic reflection contact printing
20 techniques. The presence of the strong fringe pattern on the copy will ensure that the copy is markedly different from the original version and hence this type of diffractive device in accordance with an embodiment of the invention will have a high level of optical security.

It will be appreciated that in each of these embodiments, each of a group M
25 of miniature diffraction grating groups is repeated at predetermined locations within a large array of repeat group locations. The map of these locations for each group M is determined by set of complex mapping relations between the large array and a set of invariable image component maps which act co-operatively under the control of the mapping relations to define the diffractive properties of the diffractive device
30 thereby formed on said large array. The mapping relation required to produce the type of diffractive device described in the preceding paragraph is similar to that required for the device illustrated in Figure 1 except that the generalised grating

pattern first needs to be redefined mathematically as a set of $n \times m$ small grating elements that can be interpreted as grating pixels able to be combined with the $n \times m$ pixels of the input Pixelgram-type component. This redefinition of the generalised grating can be achieved by overlying the grating with an imaginary $n \times m$ grid and
5 then calculating the average groove spacing and azimuth angle or groove orientation within each grid element or pixel. The generalised grating then becomes a set of $n \times m$ conventional straight line grating pixels of different orientations which can be fractured, sampled, displaced and interlaced with corresponding sub-pixels of the corresponding Pixelgram type grating pixels.

10 Throughout this specification and the claims which follows, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

CLAIMS

1. A pixellated diffractive device comprising a multiplicity of pixels in turn divided into multiple sub-pixels, which device is related to one or more pixellated
5 diffraction surface structures which when illuminated generate respective corresponding optically variable images, wherein the sub-pixels of each pixel of the diffractive device include diffractive elements arranged in one or more groups, the diffractive elements of each group matching diffractive elements of a corresponding single pixel of the respective said pixellated diffraction surface structures, and
10 wherein in each pixel of the device the diffractive elements of the or each said group are intermixed with other sub-pixels and cooperatively contribute a single element of the said corresponding optically variable image which is generated on illumination of the diffractive device.
- 15 2. A pixellated diffractive device according to claim 1, which generates on illumination at least two optically variable images, each associated with a respective group of diffractive elements.
3. A pixellated diffractive device according to claim 1 or 2, wherein said
20 diffractive elements are dispersed within each pixel so as to produce a predetermined discernible effect in the corresponding optically variable image.
4. A pixellated diffraction device according to claim 1 or 2, wherein said diffractive elements are dispersed within each pixel so that their relative spatial
25 arrangement is substantially different from their arrangement within a corresponding single pixel in which the diffractive elements co-operate as a contiguous surface structure.
5. A pixellated diffractive device according to any preceding claim, wherein said
30 images are the same or similar scenes but differently oriented or of different shading or colour.

6. A pixellated diffractive device according to any preceding claim, wherein one or more further groups of sub-pixels of the device collectively generate an optically invariable image.
- 5 7. A pixellated diffractive device according to any preceding claim, wherein there are at least 16 sub-pixels per pixel in a 4 x 4 array of square sub-pixels.
8. A pixellated diffractive device according to any preceding claim, wherein said pixels are sufficiently small to be below the resolution limit of a healthy human eye,
10 for example, less than 125 micron on edge.
9. A pixellated diffractive device according to any preceding claim, wherein said diffractive elements within the pixels involve classes of miniature diffraction gratings of curved and variably spaced grooves.
- 15 10. A pixellated diffractive device according to any preceding claim, wherein said diffractive elements within the pixels involve elementary arrays of polygon shaped relief structures of dimensions of the order of fractions of a micron.
- 20 11. A method of deriving at least a representation of a pixellated diffractive device, comprising a multiplicity of pixels in turn divided into multiple sub-pixels, which method comprises deriving at least a primary representation of each of one or more pixellated diffraction surface structures which when illuminated generate respective corresponding optically variable images, fracturing each pixel of the or
25 each said primary representation into multiple diffractive elements, and deriving at least a secondary representation of a pixellated diffractive device by forming each pixel thereof so that the sub-pixels thereof include or consist of diffractive elements arranged in one or more groups, the diffractive elements of each group matching diffractive elements of a corresponding single pixel of the respective said pixellated
30 diffraction surface structure, wherein in each pixel of the device, the diffractive elements of the or each said group are intermixed with other sub-pixels and cooperatively contribute a single element of the respective corresponding optically

variable image.

12. A method according to claim 11, wherein said secondary representation is a set of code or data defining the respective integer, e.g. in a computer memory means.

5

13. A method according to claim 11 or 12, wherein said deriving steps are carried out in suitably programmed computer operations.

14. A method according to claim 11, 12 and 13 further including utilising the
10 derived secondary representation to drive a suitable machine, e.g. an electron beam lithography machine, to form the actual diffractive device.

15. A method according to any one of claims 11 to 14, wherein there are at least two optically variable images, each associated with a respective said group of
15 diffractive elements of the secondary representation.

16. A method according to any one of claims 11 to 14, wherein said diffractive elements of the secondary representation are dispersed within each pixel so as to produce a predetermined discernible effect in the corresponding optically variable
20 image.

17. A method according to any one of claims 11 to 14, wherein said diffractive elements of the secondary representation are dispersed within each pixel so that their relative spatial arrangement is substantially different from their arrangement within
25 a corresponding single pixel in which the diffractive elements co-operate as a contiguous surface structure.

18. A method according to any one of claims 11 to 17, wherein said images are the same or similar scenes but differently oriented or of different shading or colour.

30

19. A method according to any one of claims 11 to 18, further including effecting said deriving, fracturing and deriving steps whereby one or more further groups of

sub-pixels of the device collectively generate an optically invariable image.

20. A method according to any one of claims 11 to 19, wherein there are at least 16 said sub-pixels per pixel in a 4 x 4 array of square sub-pixels.

5

21. A method according to any one of claims 11 to 20, wherein said pixels are sufficiently small to be below the resolution limit of a healthy human eye, for example, less than 125 micron on edge.

10 22. A method according to any one of claims 11 to 21, wherein said diffractive elements within the pixels of the device involve classes of miniature diffraction gratings of curved and variably spaced grooves.

15 23. A method according to any one of claims 11 to 22, wherein said diffractive elements within the pixels of the device involve elementary arrays of polygon shaped relief structures of dimensions of the order of fractions of a micron.

20 24. A method according to any one of claims 11 to 23, wherein the dispersal of the diffractive elements is chosen from a predetermined set of selections which therefore defines a mapping palette for the diffractive element array.

25 25. A method according to claim 24, wherein the respective diffraction surface structures forming the pixels of the pixellated diffraction surface structure are formed, in relation to predetermined variables including groove or line curvature, groove or line spacing and average groove or line orientation, from a primary palette, said mapping palette forming a secondary palette and the diffractive device entailing successive selections from both the primary and secondary palettes.

30 26. A method of forming a pixellated diffractive device in terms of a multiplicity of diffraction grating palettes wherein each palette contains miniature diffraction grating groups and each group M is in itself a sub-pixel palette of N sub-pixel diffractive elements comprising defining the device by repeating each group M at

predetermined locations within a large array of repeat group locations, the map of repeat group locations for each group M being determined by a set of complex mapping relations between the large array and a set of invariable image component maps which act co-operatively under the control of the mapping relations to define
5 the diffractive properties of the diffractive device thereby formed on said large array.

27. A pixellated diffractive device formed by the method of claim 26.

28. A stored set of data defining a pixellated diffractive device according to any
10 one of claims 1 to 10 or 27.

1/2

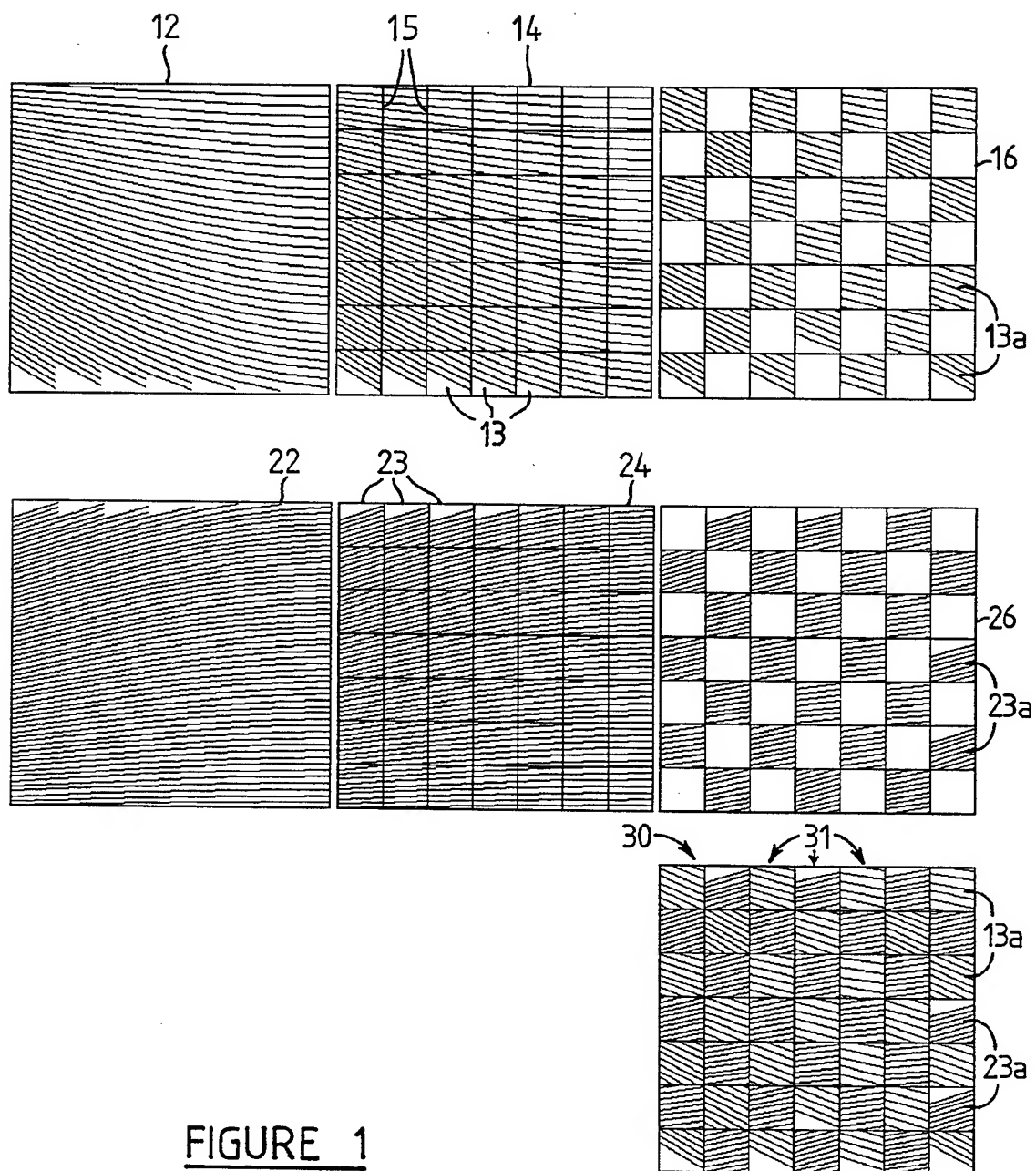


FIGURE 1

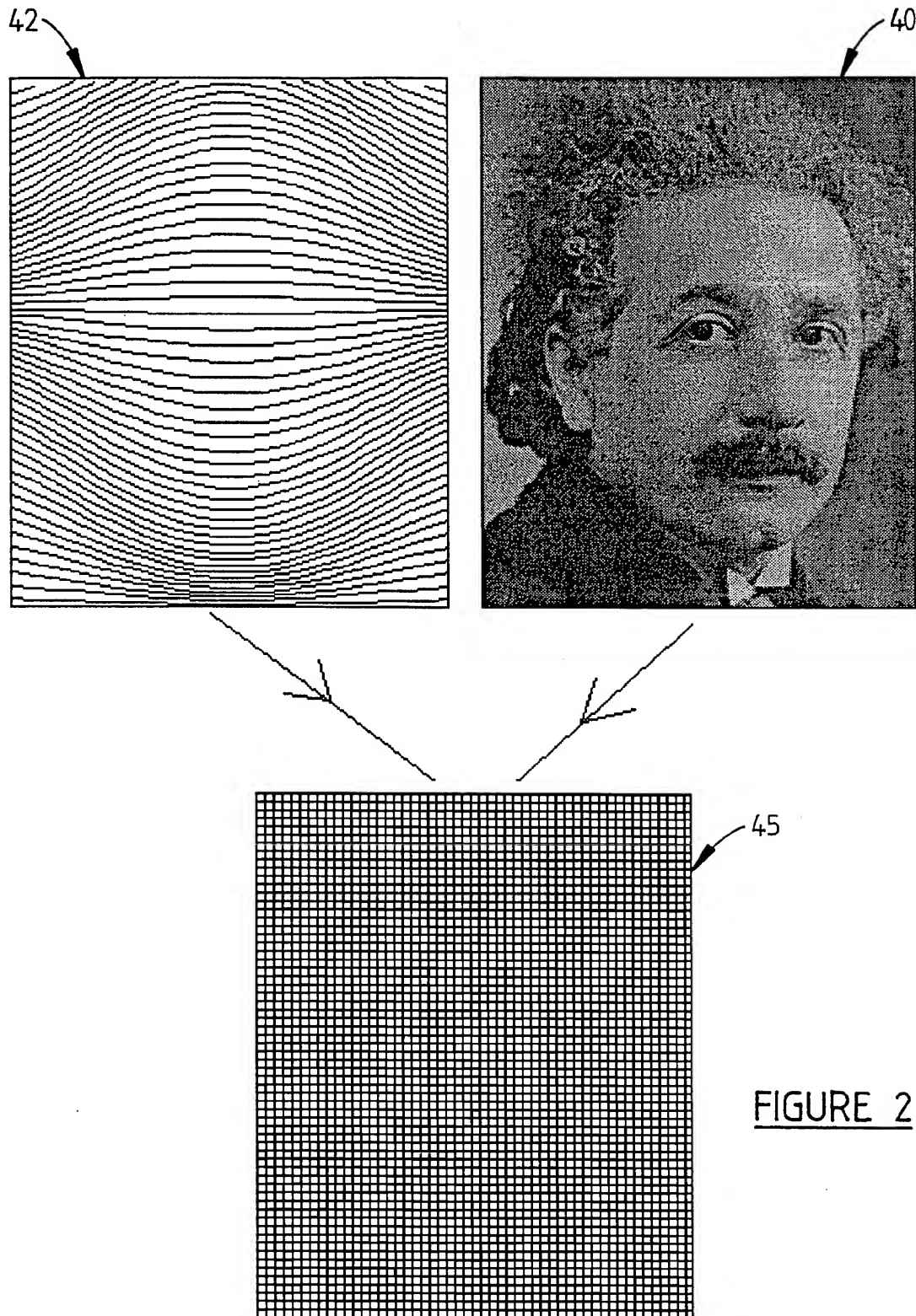
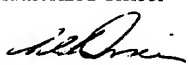


FIGURE 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 94/00279

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. ⁵ G02B 5/18, 27/44, B44F 1/12, B42D 15/10, 209:00 According to International Patent Classification (IPC) or to both national classification and IPC					
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC G02B 5/18, 27/44, B44F 1/12, B42D 15/10, 209:00, G06K 19/08, 19/16 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU : IPC as above Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT : pixel and (diffract or relief structure) JAPIO : pixel and (diffract or relief structure)					
C. DOCUMENTS CONSIDERED TO BE RELEVANT					
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.			
P,A	AU,A, 37390/93 (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION) 5 October 1993 (05.10.93)				
A	AU,A, 19096/92 (MIKOH PTY LTD) 8 January 1993 (08.01.93) page 34, line 10 - page 35, line 14; page 38, lines 31-35; page 40, lines 18-22; page 66, lines 9-27; Fig. 12				
A	AU,B, 10499/92 (641840) (TOPPAN PRINTING CO. LTD) 13 August 1992 (13.08.92)				
(continued)					
<div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. </div> <div> <input checked="" type="checkbox"/> See patent family annex. </div> </div>					
<table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;"> * Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width: 33%; vertical-align: top;"> "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family </td> <td style="width: 33%;"></td> </tr> </table>			* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family				
Date of the actual completion of the international search 25 August 1994 (25.08.94)		Date of mailing of the international search report 16 Sept 1994 (16.09.94)			
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929		Authorized officer  M.E. DIXON Telephone No. (06) 2832194			

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 94/00279

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	AU,B, 62828/90 (649625) (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION) 8 April 1991 (08.04.91)	
A	AU,B, 53729/90 (635255) (LANDIS & GYR BETRIEBS AG) 24 October 1991 (24.10.91) (& US,A, 5032003 & EP,A1, 0375833)	
A	AU,B, 48110/90 (633862) (RESERVE BANK OF AUSTRALIA) 10 July 1990 (10.07.90)	
A	AU,B, 19576/83 (561688) (LGZ LANDIS AND GYR ZUG AG) 12 April 1984 (12.04.84)	
A	EP,A2, 0467601 (APPLIED HOLOGRAPHICS CORPORATION) 22 January 1992 (22.01.92)	
A	EP,A2, 0240261 (XEROX CORPORATION) 7 October 1987 (07.10.87)	
A	EP,A2, 0240262 (XEROX CORPORATION) 7 October 1987 (07.10.87)	
A	Patent Abstracts of Japan, P-1057, page 1, JP,A, 2-72320 (TOPPAN PRINTING CO. LTD) 12 March 1990 (12.03.90)	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	19096/92	WO	9222039				
AU	10499/92	EP	497292	JP	4311916		
AU	48110/90	CA WO	2006056 9007133	EP	449893	NZ	231877
AU	19576/83	AT US	17685 4568141	CH	659433	EP	105099
AU	62828/90	CA	2065309	EP	490923	WO	9103747
EP	240261	JP	62232615	US	4737448		
EP	240262	JP	62232616	US	4788116		
AU	37390/93	WO	9318419				
END OF ANNEX							